SYSTEMS AND METHODS FOR CONTROLLING A RESONANT DEVICE FOR GENERATING VIBROTACTILE HAPTIC EFFECTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Nos. 60/631,649, filed Nov. 30, 2004, entitled "Systems and Methods for Controlling a Resonant Device" and 60/634,212, filed Dec. 8, 2004, entitled "Systems and Methods for Controlling a Resonant Device", the entirety of both of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention generally relates to haptic feedback device control. The present invention more particularly relates to systems and methods for controlling a resonant device.

BACKGROUND

[0003] Electronic device manufacturers strive to produce a rich interface for users. Conventional devices use visual and auditory cues to provide feedback to a user. In some interface devices, kinesthetic feedback (such as active and resistive feedback) and/or tactile feedback (such as vibration, texture, and heat) is also provided to the user, more generally known collectively as "haptic feedback." Haptic feedback can provide cues that enhance and simplify the user interface. Specifically, vibration effects, or vibrotactile haptic effects, may be useful in providing cues to users of electronic devices alerting the user to specific events, or in providing realistic feedback to create greater sensory immersion within a simulated or virtual environment.

[0004] For example, cell phones are commonly equipped with auditory and visual cues indicating an incoming telephone call. Visual cues typically include flashing lights. Auditory cues typically include a series of tones, synthesized music, or, more recently, digitally-recorded music. However, in some instances, such visual and auditory cues may not be useful to a user of the cell phone. For example, a user in a movie theater will typically have the phone's audible ringer silenced and will have the phone in a pocket and be unable to view the visual cues. In such instances, vibrotactile haptic effects are desirable.

[0005] Further, highly configurable and distinctive vibrotactile haptic effects may be desirable. For example, cell phones commonly allow a user to assign specific tones or melodies to identify incoming phone calls from specific numbers. A user may have different audible ring tones for different friends, for work, and for family members. Such differentiation of audible cues allows a user to quickly recognize not only that there is an incoming phone call, but also whom that call is from. However, as described above, in many settings, such differentiation is not possible using standard cell phones. Such phones typically have only a simplistic set of vibrations to indicate an incoming telephone call, but no mechanism for efficiently and effectively generating differentiable vibrotactile haptic effects.

SUMMARY

[0006] The present invention provides systems and methods for controlling a resonant device. One embodiment of the present invention provides a method for braking an actuator comprising generating a first actuator signal, the first actuator signal having a first frequency approximately resonant to the actuator. The first actuator signal is configured to drive the actuator. The method further comprises transmitting the first actuator signal to the actuator. The method next comprises a step for generating a second actuator signal having a second frequency approximately 180 degrees out of phase to the first frequency. The second actuator signal is configured to cause a braking force on the actuator. The method additionally comprises transmitting the second actuator signal to the actuator. In another embodiment, a computer-readable media comprises code for a carrying out such a method.

[0007] These illustrative embodiments are mentioned not to limit or define the invention, but to provide examples to aid understanding thereof. Illustrative embodiments are discussed in the Detailed Description, and further description of the invention is provided there. Advantages offered by various embodiments of this invention may be further understood by examining this specification.

BRIEF DESCRIPTION OF THE FIGURES

[0008] These and other features, aspects, and advantages of the present invention are better understood when the following Detailed Description is read with reference to the accompanying drawings, wherein:

[0009] **FIG. 1** is a block diagram illustrating a system for controlling a resonant device in one embodiment of the present invention;

[0010] **FIG. 2** is a flowchart illustrating a method for braking an actuator in one embodiment of the present invention;

[0011] **FIG. 3** is a block diagram illustrating components of a signal generator in one embodiment of the present invention;

[0012] **FIG. 4** shows two graphs illustrating a simulated low frequency wave using a vibrotactile haptic effect envelope and a resonant actuator with a higher frequency than the vibrotactile haptic effect envelope in one embodiment of the present invention;

[0013] **FIG. 5** is a circuit diagram of a signal generator in one embodiment of the present invention; and

[0014] **FIG. 6** shows a graph illustrating the inversion of a signal driving a resonant actuator and a graph illustrating a comparison between the motion of a first resonant actuator driven by the signal and the motion of a second resonant actuator allowed to return to rest without braking in one embodiment of the present invention.

DETAILED DESCRIPTION

[0015] Embodiments of the present invention provide systems and methods for controlling a resonant device.

Illustrative Controlling a Resonant Device

[0016] In one embodiment of the present invention, a cell phone has a resonant system for generating vibrations. The resonant system comprises a resonant actuator and is controlled by a processor that sends signals to the resonant